TITLE OF THE INVENTION

VALVE TIMING ADJUSTING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a valve timing adjusting apparatus adjusting the opening/closing timing of an intake valve or exhaust valve abutting a cam fixed to an intake camshaft or exhaust camshaft of an internal combustion engine (hereinafter referred to simply as an "engine").

Description of the Related Art

Conventionally, a valve timing adjusting apparatus is generally composed of a first rotor that is connected with a crank shaft of an engine by a power transmitting member such as a chain, and rotates synchronously with the crank shaft, and a second rotor that is integrally fixed to the end face of the intake camshaft or exhaust camshaft, and relatively rotatably provided within the first rotor by a predetermined angle.

The first rotor is constructed by integrally assembling, with a plurality of first fastening members, a housing that has a sprocket being subject to the rotary driving force of the crank shaft and a bearing slidingly contacted with the outer peripheral surface in the proximity of the end face of the intake camshaft or exhaust camshaft, a case that is adjacent to this housing and has a plurality of hydraulic chambers inside ther of, and a cover that cov rs the hydraulic chambers of this case.

Th hydraulic chamb rs of the case are form d of a plurality of sho s projecting radially inwardly within th case.

The second rotor is generally composed of a boss fixed to the end face of the intake camshaft or the exhaust camshaft, and a plurality of vanes projecting radially outwardly from the outside of the boss to divide each of the above-mentioned hydraulic chambers into an advance side hydraulic chamber being subject to the hydraulic pressure that rotates the second rotor to the advance side and a lag side hydraulic chamber being subject to the hydraulic pressure that rotates the second rotor to the lag side. The advance side hydraulic chamber is connected with a first oil passage formed in the intake camshaft or the exhaust camshaft, and the lag side hydraulic chamber is connected with a second oil passage formed in the intake camshaft or the exhaust camshaft. These first oil passage and second oil passage are connected with an oil pump and an oil pan through an oil control valve (hereinafter referred to as an OCV).

Within one of the shoes of the case of the first rotor, for instance, is provided a lock pin that is radially inwardly urged by urging means and projects to the second rotor side. On the other hand, at the outer peripheral of the boss of the second rotor is formed an engaging hole receiving therein the lock pin when the relative rotation between the first rotor and the second rotor is regulated at the time of starting or stopping the engine, for instance. The engaging hole is form d at the position in which the second rotor is most advanced relative

to th first rotor (hereinafter r f rr d to as th most advanced position), at th position in which the s cond rotor is most lagged relative to the first rotor (hereinafter referred to as the most lagged position), or at the position located between the most advanced position and the most lagged position (hereinafter referred to as the intermediate position).

The operation of the related art will now be described below.

First of all, because remaining oil within the advance side hydraulic chamber and the lagged side hydraulic chamber of the valve timing adjusting apparatus is returned to the oil pan through the first oil passage, the second oil passage, and the OCV when the engine is stopped or immediately after the engine is started, the relative rotation between the first rotor and the second rotor is regulated by the aid of the engagement of the lock pin with the engaging hole, by an urging force of the urging means (the state is called as a "rotation regulating state" or "locking state.").

When the oil pump is subsequently driven by the engine start-up, the oil is supplied to the advance hydraulic chamber or the lag side hydraulic chamber of the valve timing adjusting apparatus through the OCV. Because the lock pin is radially outwardly forced back against the urging force of the urging member, and comes out of the engaging hole when the advance side hydraulic pressure or the lag side hydraulic pressure is applied to th lock pin, th first rotor and the second rotor can relatively rotate by the pred termined angle by the advance side

hydraulic pr ssur or the lag side hydraulic pressur (th stat is called as a "rotating regulation r leasing stat " or "lock releasing state.") (Refer to Patent Document 1, for instance).

Patent Document 1:

"Japanese Patent Application Laid-Open No.2002-155713" (Claim 3 and FIG. 3)

However, the conventional valve timing adjusting apparatus thus arranged as mentioned above involves the following problems.

Where the intermediate maintaining control is performed in which the second rotor is maintained at the intermediate position relative to the first rotor when the engine is running, simultaneous stoppage of the supply of the advance side hydraulic pressure and the lag side hydraulic pressure (actually, only the few advance side hydraulic pressure is supplied) with the OCV can radially inwardly advance the lock pin by the urging force of the urging member. Specifically, where the engaging hole is formed at the intermediate position, the intermediate maintaining control is done in the proximity of the engaging hole, which renders maintaining the lock releasing state unfeasible, thereby resulting in the re-engagement of the lock pin with the engaging hole.

In the conventional valve timing adjusting apparatus, both of the advance side hydraulic pressure and the lag side hydraulic pressure are controlled to disengage the lock pin from the ngaging hol and r lease th rotating regulation. Howev r, the expansion of th hydraulic chamber accompanied with th

relativ rotation b twe n th first rotor and the second rotor during th relativ rotation reduces th lock releas maintaining hydraulic pressure, acting on the tip end of the lock pin to half or so the level of the hydraulic pressure supplied by the engine. For this reason, the lock releasing state cannot be maintained. Thus, when carrying out the relative rotation of the apparatus within the range where the lock pin bridges over the engaging hole, the lock pin re-engages with the engaging hole during the relative rotation, and therefore the valve timing adjusting apparatus can be incapable of rotating to the desired rotating position.

In addition, since the re-engagement of the lock pin with the engaging hole is difficult to detect, and the relative rotating operation of the second rotor relative to the first rotor goes faster than the lock releasing operation to retract the lock pin when a control command indicative of a change in the relative angle between both the rotors is given in the case where once the lock pin entered the engaging state with the engaging hole, and the hydraulic pressure is supplied to the hydraulic chamber, the sticking is produced between the internal surface of the lock pin and the internal surface of the engaging hole, which impedes the smooth lock releasing.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above-m ntioned problems. An object of the pres nt invention is to provide a valv timing adjusting apparatus including a

mechanism pr venting th occurr nc of the accidental r - ngag m nt during the r lativ rotation b tw n both the rotors after the lock is released.

The valve timing adjusting apparatus according to the present invention includes a first rotor rotating synchronously with a crank shaft of an internal combustion engine; a second rotor fixed to the end face of an intake or exhaust camshaft thereof and relatively rotatably provided within the first rotor by a predetermined angle; a rotation regulating member provided within either the first rotor or the second rotor, regulating the relative rotation between the first rotor and the second rotor when the relative position between both the rotors reached a predetermined position; and an engaging hole formed within either the first rotor or the second rotor, receiving therein the engagement of the rotation regulating member at the time of regulation of the relative rotation between both the rotors, and is closed after the regulation of the relative rotation between both the rotors is released.

Therefore, according to the present invention, it securely prevents re-engagement of the rotation regulating member with the engaging hole that is closed during the relative rotation between both the rotors after the lock is released.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial sectional view showing the internal structure of the valve timing adjusting apparatus according to a first embodiment;

FIG. 2 is a radial sectional vi w taken along lin II-II in FIG. 1;

FIG. 3 is an enlarged radial sectional view showing the locking state of the first rotor and the second rotor in the valve timing adjusting apparatus shown in FIG. 1 and FIG. 2;

FIG. 4 is an enlarged radial sectional view showing the lock releasing state of the first rotor and the second rotor in the valve timing adjusting apparatus shown in FIG. 1 and FIG. 2;

FIG. 5 is an enlarged radial sectional view showing the sliding state of the locking member in the valve timing adjusting apparatus shown in FIG. 4 when the lock is released;

FIG. 6 is a schematic diagram showing the overall structure of an hydraulic pressure supplying and exhausting system in which the valve timing adjusting apparatus shown in FIGS. 1 to 5 is incorporated;

FIG. 7 is an axial sectional view showing the internal structure of the valve timing adjusting apparatus according to a second embodiment;

FIG. 8 is a radial sectional view taken along line VIII-VIII in FIG. 7;

FIG. 9 is an enlarged schematic perspective view showing the purview of FIG. 8;

FIG. 10 is an enlarged radial sectional view showing the locking state of the first rotor and the second rotor in the valve timing adjusting apparatus shown in FIGS. 7-9;

FIG. 11 is an enlarged radial sectional view showing the

lock r l asing state of the first rotor and th second rotor in the valve timing adjusting apparatus shown in FIGS. 7-9; and

FIG. 12 is a schematic diagram showing the overall structure of an hydraulic pressure supplying and exhausting system in which the valve timing adjusting apparatus shown in FIGS. 7-11 is incorporated.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described hereinafter with reference to the attached drawings.

First Embodiment

FIG. 1 is an axial sectional view showing the internal structure of the valve timing adjusting apparatus according to the first embodiment. FIG. 2 is a radial sectional view taken along line II-II in FIG. 1. FIG. 3 is an enlarged radial sectional view showing the locking state of the first rotor and the second rotor in the valve timing adjusting apparatus shown in FIG. 1 and FIG. 2. FIG. 4 is an enlarged radial sectional view showing the lock releasing state of the first rotor and the second rotor in the valve timing adjusting apparatus shown in FIG. 1 and FIG. 2. FIG. 5 is an enlarged radial sectional view showing the sliding state of the locking member in the valve timing adjusting apparatus shown in FIG. 4 when the lock is r l as d. FIG. 6 is a sch matic diagram showing the ov rall structur of an hydraulic pressur supplying and xhausting

system in which th valv timing adjusting apparatus shown in FIGS. 1 to 5 is incorporated.

Referring to FIGS 1 to 6, reference numeral 1 denotes a valve timing adjusting apparatus that is generally composed of a first rotor 10 connected with the crank shaft (not shown) of an engine (not shown) with a power transmitting member (not shown) such as a chain and rotates synchronously with the above-mentioned crank shaft, and a second rotor 30 that is integrally fixed to the end face of an intake side or exhaust side camshaft (hereinafter referred to as a camshaft) 20 with a bolt 21 and relatively rotatably provided within the first rotor 10 by a predetermined angle. This valve timing adjusting apparatus 1 is a so-called intermediate lock type valve timing adjusting apparatus in which the rotation of the second rotor 30 relative to the first rotor 10 is regulated at the intermediate position between the most advanced position and the most lagged position, which is the relative position between the first rotor 10 and the second rotor 30. The valve timing adjusting apparatus, as will be described later, has a so-called radial direction lock structure in which a rotation regulating member regulating the relative rotation between the first rotor 10 and the second rotor 30 is slidably provided on the first rotor 10 side in the radial direction of the valve timing adjusting apparatus 1, and the engaging hole engaging therein the rotation regulating member is formed on the second rotor 30 sid .

The first rotor 10 is generally composed of a housing 11

that is integrally provided with a sprocket 11a to b subject to th rotary driving force of th above-m ntioned crank shaft and is internally provided with a slidingly contacting portion 65 slidingly contacting the outer peripheral surface of the camshaft 20 located in the proximity of its end face; a case 12 that is provided adjacent to this housing 11 and has a plurality of (four in the first embodiment) shoes 12a, 12b, 12c, and 12d for radially inwardly projecting and forming a plurality of spaces; and a cover 13 that covers the interstice of this case 12, the first rotor being integrally fastened to the apparatus with bolts 14.

The second rotor 30 is, as shown in FIG. 1, a rotor (the second rotor 30 is referred to as a "rotor 30" hereinafter) having a boss 30a integrally fastened to the end face of the camshaft 20 with a bolt 21 and a plurality of (four in the first embodiment) vanes 30b, 30c, 30d, and 30e radially outwardly projecting from the outer peripheral of the boss 30a. The vane 30b of the rotor 30 divides the space formed between the shoe 12d and the shoe 12a of the case 12 into an advance side hydraulic pressure chamber 31a and a lag side atmospheric pressure chamber 32a; the vane 30c divides the space formed between the shoe 12a and the shoe 12b into an advance side atmospheric pressure chamber 31b and a lag side hydraulic pressure chamber 32b; the vane 30d divides the space formed between the shoe 12b and the shoe 12c into an advance side hydraulic pressure chamber 31c and a lag side hydraulic pr ssure chamb r 32c; and the vane 30 divides th space formed b tween the sho 12c and the shoe 12d

into an advanc sid hydraulic pr ssur chamber 31d and a lag side hydraulic pressure chamber 32d.

As shown in FIG. 1, in each of the tip ends of the shoes 12b, 12c, and 12d other than the shoe 12a of the case 12 in the first embodiment, are provided seal members 33a, 33b, and 33c preventing hydraulic fluid standing between the advance side hydraulic pressure chamber 31a and the lag side hydraulic pressure chamber 32d, between the advance side hydraulic pressure chamber 31c and the lag side hydraulic pressure chamber 32b, and between the advance side hydraulic pressure chamber 31d and the lag side hydraulic pressure chamber 32c from flowing, to thereby maintain the pressure within each of the chambers. Moreover, in each of the tip ends of the vanes 30b, 30c, 30d, and 30e of the rotor 30 are provided seal members 33d, 33e, 33f, and 33g preventing hydraulic fluid standing between the advance side hydraulic pressure chamber 31a and the lag side atmospheric pressure chamber 32a, between the advance side atmospheric pressure chamber 31b and the lag side hydraulic pressure chamber 32b, between the advance side hydraulic pressure chamber 31c and the lag side hydraulic pressure chamber 32c, and between the advance side hydraulic pressure chamber 31d and the lag side hydraulic pressure chamber 32d from flowing, to thereby maintain the pressure within each of the chambers. As shown in FIG. 2, the seal member 33c, for instance, is generally composed of a seal 34 formed of flexible resin and a board spring 35 pressing the s al 34 on the out r peripheral surface 30f of th rotor 30, and the other seal members have similar

structur s.

Moreover, assist springs 37 each held in hold rs 36 are provided between the shoe 12d of the case 12 and the vane 30b of the rotor 30, between the shoe 12b of the case 12 and the vane 30d of the rotor 30, and between the shoe 12c of the case 12 and the vane 30e of the rotor 30. This assist springs 37, in the state in which hydraulic pressure is not supplied when the engine is stopped or started, continuously urges the rotor 30 relative to the case 12 in the advance direction (in the direction of arrow X in FIG. 1) against the valve reaction force being subject to by the camshaft 20 in the lag direction (in the direction of arrow Y in FIG. 1). In addition, holders 36 improve the assemblage of the assist springs 37 and prevent a plurality of assist springs 37 from interfering with one another.

Inside the boss 30a of the rotor 30 and the camshaft 20 are provided a first oil passage 38 communicating with the advance side hydraulic pressure chambers 31a, 31c, and 31d other than the advance side hydraulic pressure chamber 31b, and supplying thereto and exhausting therefrom hydraulic pressure, and a second oil passage 39 communicating with the lag side hydraulic pressure chambers 32b, 32c, and 32d other than the lag side atmospheric pressure chamber 32a, and supplying thereto and exhausting therefrom hydraulic pressure. The first oil passage 38 and the second oil passage 39 are arranged as shown in FIG. 6 to supply th reto and exhaust therefrom hydraulic pressur by an oil pump 41 and an oil pan 42 through

an OCV 40. Although th structur in which hydraulic pr ssure is not suppli d to the advance sid atmosph ric pr ssur chamb r 31b and the lag side atmospheric pressure chamber 32a, an advance side drain passage 43 and a lag side drain passage 44 opened to the atmosphere, for discharging oil are provided within the advance side atmospheric pressure chamber 31b and the lag side atmospheric pressure chamber 32a, respectively, as shown in FIG. 1.

A lock pin receiving hole 50 radially passing through the shoe 12a is formed only in the shoe 12a out of the shoes of the case 12, disposed between the advance side atmospheric pressure chamber 31b and the lag side atmospheric pressure chamber 32a. In the lock pin receiving hole 50 is slidably provided a lock pin (rotation regulating member) 51 in an axial direction of the lock pin receiving hole 50, regulating the relative rotation between the case 12 and the rotor 30 when the engine is stopped or started, and permitting the relative rotation when the engine is running. The lock pin 51 is generally composed of a cylindrical pin body 51a and a non-through hole 51b that is formed at the bottom of the pin body 51a along an axial direction of the pin body.

Moreover, in the portion of the lock pin receiving hole 50 in the proximity of the outer peripheral surface of the case 12 is inserted a bush 52 having a non-through hole 52a, and this bush 52 is positioned and secured thereon by a shaft 53 inserted therein along an orthogonal direction crossing th axial direction of th lock pin receiving hol 50. Betw en the

non-through hole 52a of the bush 52 and th non-through hol s 51b of the lock pin 51 opposing to the non-through hol 52a is provided a coil spring 54 that continuously urges the lock pin 51 in the direction of arrow Z1. At the bottom of the non-through hole 52a of the bush 52 is formed a back pressure drain passage 52b for exhausting back pressure developed within the lock pin receiving hole 50, to the atmosphere, when the lock pin 51 retreats in the direction of arrow Z2.

On the other hand, a slider receiving hole 55 for receiving the lock pin 51 is formed along a radial direction in the intermediate position that is a position opposed to the shoe 12a of the case 12, and is away from both of the most advanced position in which the shoe 12a and the vane 30b of the rotor 30 abut each other and the most lagged position in which the shoe 12a and the vane 30c abut each other, in the outer peripheral of the boss 30a of the rotor 30. The slider receiving hole 55 has an internal diameter that is slightly larger than the external diameter of the lock pin 51. The slider receiving hole 55 has a bottom 55a, and in the bottom 55a is formed one end of a third oil passage 56 for supplying hydraulic pressure into the slider receiving hole 55. The third oil passage 56 is arranged, as shown in FIG. 6, to supply thereto and exhaust therefrom hydraulic pressure by the oil pump 41 and the oil pan 42 through an opening/closing control valve 57 independent of the first oil passage 38 and the second oil passage 39 extending through th OCV 40.

Mor ov r, within the slid r receiving hol 55 is provided

a slider (closing m mber) 58 that is slidabl in an axial direction of th slid r r c iving hol 55, and a bush 59 is press-fitted into a position located in the proximity of the outer peripheral surface 30f of the rotor 30, in the slider receiving hole 55. The slider 58 is a sliding member that pushes back in the direction of arrow Z2 the lock pin 51 to be engaged with an engaging hole 59a of the bush 59 press-fitted into the slider receiving hole 55 against the urging force of the coil spring 54. The slider is generally composed of a thin portion 58a having an external diameter substantially equal to that of the pin body 51a of the lock pin 51; a thick portion 58b located closer to the bottom 55a side of the slider receiving hole 55 than this thin portion 58a; and a concave 58c formed on the bottom of this thick portion 58b for forming an internal space between the bottom of the slider 58 and the bottom 55a of the slider receiving hole 55, which causes hydraulic pressure supplied to the slider receiving hole 55 from the third oil passage 56 to promptly act on the whole bottom of the slider 58 even when the slider 58 retreats and is in contact with the bottom 55a of the slider receiving hole 55.

Within the bush 59 is formed the engaging hole 59a passing through the bush in an axial direction of the bush and engaging therein the lock pin 51. The inner peripheral surface of the engaging hole 59a has an internal diameter enough for the pin body 51a of the lock pin 51 and the thin portion 58a of the slider 58 to slide therein, and th axial l ngth of the engaging hole is arranged to b substantially equal to that of the thin portion

58a of the slider 58. Th r for , as shown in FIG. 4, wh n the thin portion 58a of the slider 58 slid by hydraulic pr ssur , in the direction of arrow Z2 within the engaging hole 59a of the bush 59, the tip end surface 58d of the thin portion 58a of the slider 58 becomes substantially flush with the top surface 59c of the bush 59 at the time the slide is stopped by the abutment of the thick portion 58b of the slider 58 on bottom surface 59b of the bush 59. At that time, because the outer peripheral surface 30f of the rotor 30, the top surface 59c of the bush 59, and the tip end surface 58d of the slider 58 are consecutively subject to the slide of the tip end surface 51c of the lock pin 51 when the lock pin 51 retreats in the direction of arrow Z1 (in the lock releasing state), ideally, each of the above-mentioned surfaces should be flush with one another. However, as a practical matter, it is necessary to consider errors in the machining accuracy in the assembly stage. That is, as shown in FIG. 5, when the top surface 59c of the bush 59 is retained within the slider receiving hole 55 formed on the lower side such that the top surface does not project outwardly from the outer peripheral surface 30f of the rotor 30, and further the tip end surface 58d of the thin portion 58a of the slider 58 sliding within the engaging hole 59a of the bush 59, slightly project from the top surface 59c of the bush 59, the top surface 59c of the bush 59 will slightly be recessed from the outer peripheral surface 30f of the rotor 30 and the tip end surface 58d of the slider 58. However, since th width of th recess is much shorter than that of the lock pin 51, the

lock pin 51 do s not go in th abov -mention d r cess, nor do s it stick ther in, which allows smooth sliding of the lock pin 51 on the outer peripheral surface 30f of the rotor 30. In addition, as shown in FIG. 5, the convexly curved tip end surface 51c of the lock pin 51 relative to the slider receiving hole 55 avoids sticking the corner of the tip end surface 51c of the lock pin 51 in the recess, thereby ensuring the stability of the relative rotation between the case 12 and the rotor 30. If it is tentatively arranged without entirely considering errors in the machining accuracy, that the top surface 59c of the bush 59 and the tip end surface 58d of and the slider 58 becomes flush with each other relative to the outer peripheral surface 30f of the rotor 30, there is a possibility that the tip end surface 58d of the slider 58 will lower from the top surface 59c of the bush 59, with the result that the lock pin 51 will engage with the recess when the length of the thin portion 58a of the slider 58 is shorter than that of the engaging hole 59a of the bush 59. Conversely, when the length of the thin portion 58a of the slider 58 is longer than that of the engaging hole 59a of the bush 59, it is feared that the tip end surface 58d of the slider 58 will project from the outer peripheral surface 30f of the rotor 30 and the top surface 59c of the bush 59, and the lock pin 51 will stick thereon, which blocks the relative rotation between the case 12 and the rotor 30.

The operation of the first embodiment will now be described b low.

First of all, becaus the oil pump 41 shown in FIG. 6 is

not driv n wh n the ngin is stopped, th r maining oil in th valve timing adjusting apparatus 1, in th first oil passage 38, and in the second oil passage 39 is flowed down to the oil pan 42. At that time, since the opening/closing control valve 57 is closed, and the hydraulic pressure is not supplied to the third oil passage 56, lock releasing hydraulic pressure is not supplied into the slider receiving hole 55 from the third oil passage 56, and the slider 58 in the slider receiving hole 55 does not act on the lock pin 51. Therefore, as shown in FIG. 3, the lock pin 51 slides in the direction of arrow Z1 by the urging force of the coil spring 54, and engages with the engaging hole 59a of the bush 59. The tip end surface 51c of the lock pin 51 abuts the tip end surface 58d of the thin portion 58a of the slider 58, thereby retreating the slider into a retreating space 55b on the bottom 55a side of the slider receiving hole 55. This regulates the relative rotation between the case 12 and the rotor 30 (the locking state).

Subsequently, because it is difficult to control the relative rotating portion between the first rotor and second rotor of the valve timing adjustment apparatus 1 at the desired position on account of a low temperature and a high viscosity of the oil immediately after the engine is started and the pump 41 shown in FIG. 6 is driven, the opening/closing control valve 57 is closed, and the slider 58 does not act on the lock pin 51, which maintains the locking state. Since the hydraulic pr ssur is not suppli d to the advanc sid atmosph ric pressure chamber 31b and the lag side atmospheric pressure

chamb r 32a adjacent to th sho 12a of th case 12 in which the lock pin 51 is provided, the hydraulic pr ssur does not act on the tip end surface 51c of the lock pin 51 through the clearance between the tip end surface of the shoe 12a and the outer peripheral surface 30f of the rotor 30. Accordingly, even in this regard, accidental releasing of the locking state is not done. In the event that the oil enters the advance side atmospheric pressure chamber 31b and the lag side atmospheric pressure chamber 32a, the oil is promptly discharged through the advance side drain passage 43 and the lag side drain passage 44.

Then, when the engine warming up is ended, the oil gets to have a high temperature and a low viscosity. At this stage, it becomes fairly possible to control the relative rotation between the first rotor and the second rotor of the valve timing adjusting apparatus 1 at the desired position. Now, upon giving a control instruction, the opening/closing control valve 57 shown in FIG. 6 is operated to change from the closing state to the opening state in which the hydraulic pressure is supplied to the third oil passage 56, and the hydraulic pressure (the lock releasing hydraulic pressure) is supplied from the third oil passage 56 to the internal space formed between the bottom 55a of the slider receiving hole 55 and the concave 58c of the slider 58. As shown in FIG. 4, the slider 58 slides by the above-mentioned hydraulic pressure in the direction of arrow Z2 until th thick portion 58b of th slider 58 abuts th bottom surfac 59b of th bush 59 and the thick portion stops. Further,

th slid r retr ats the lock pin 51 into th lock pin receiving hole 50 against the urging force of the coil spring 54 to mak the lock pin come out of the engaging hole 59a of the bush 59 in the slider receiving hole 55, and at the same time closes the engaging hole 59a of the bush 59 formed within the slider receiving hole 55. At that time, when the lock pin 51 completely came out of the engaging hole 50, the engagement of the lock pin and the engaging hole is released, and the relative rotation between the case 12 and the rotor 30 is permitted (the lock releasing state). This lock releasing state is securely maintained, because the engaging hole 59a of the bush 59 in the slider receiving hole 55 is closed by the slider 58 slid by the lock releasing hydraulic pressure as long as the lock releasing hydraulic pressure is supplied into the slider receiving hole 55 through the third oil passage 56 with the opened opening/closing control valve 57.

Moreover, since the third oil passage 56 is constructed independently of the first oil passage 38 and the second oil passage 39 communicating with the advance side hydraulic pressure chambers 31a, 31c, and 31d, and the lag side hydraulic pressure chambers 32b, 32c, and 32d in which the hydraulic pressure fluctuations accompanied with the change in the relative angle between the case 12 and the rotor 30 takes place when the engine is running, the third oil passage 56 is free from influences by the fluctuations in the above-mentioned hydraulic pressure, thus nabling continuos application of a constant lock releasing hydraulic pressure to the slider 58.

In addition, b cause the advance side atmosph ric pr ssure chamber 31b and the lag side atmospheric pr ssur chamb r 32a adjacent to the shoe 12a of the case 12 is opened to the atmosphere through the advance side drain passage 43 and the lag side drain passage 44, and further the space corresponding to the back of the lock pin 51 within the lock pin receiving hole 50 is opened to the atmosphere through the atmosphere communicating hole (not shown) of the bush 54 press-fitted in the lock pin receiving hole 50, the slider 58 is subject to extremely small sliding resistance when the slider slides in the direction of arrow Z2 by the lock releasing hydraulic pressure from the third oil passage 56. Accordingly, the slider 58 can promptly slide by the applied lock releasing hydraulic pressure to push the lock pin 51 out of the engaging hole 59a, and to close the engaging hole 59a.

The urging force of the coil spring 54, for instance, is set such that the slider 58 slides against the urging force of the coil spring 54 to thereby maintain the lock releasing state even when the lock releasing hydraulic pressure applied to the slider 58 is in the state of the high oil temperature when the engine is running or in the lowest hydraulic pressure at the time of the low-speed rotation.

Since the lock pin 51 is continuously urged in the direction of arrow Z1 by the urging force of the coil spring 54 even when the engine is running, the lock pin slides on the out r peripheral surface 30f of th rotor 30 b tween the vane 30b and the vane 30c thereof during the r lativ rotation

b tween the case 12 and the rotor 30. On the other hand, b caus the engaging hole 59a is always closed by the slider 58, the lock pin 51 is securely prevented from re-engaging with the engaging hole 59a no matter whatever the valve timing adjusting apparatus 1 is in controlling state. For instance, when performing the intermediate maintaining control in which the relative angle between the case 12 and the rotor 30 is controlled such that the shoe 12a of the case 12 is maintained in the intermediate position where the shoe 12a of the case 12 is apart from both of the vane 30b and the vane 30c of the rotor 30, the lock pin 51 will slide in the proximity of the engaging hole 59a. However, even in this case, because the engaging hole 59a is closed by the slider 58, the lock pin 51 is securely prevented from re-engaging with the engaging hole 59a.

In addition, once the engine stopped, the remaining oil within the first oil passage 38 and the second oil passage 39 flows down to the oil pan 42, and air comes to stay in each oil passage. If the engine is re-started under such a condition, it is difficult to control the valve timing adjusting apparatus 1 in the substantially intermediate position between the most advanced position and the most lagged position for the reason that the oil supplied from the first oil passage 38 and the second oil passage 39 into the valve timing adjusting apparatus 1 contains air therein even through the oil has a high temperature and a low viscosity. Even in such a condition, closing the op ning/closing control valv 57 allows stoppage of th supply of the hydraulic pressure for lock rel asing to th slider 58

to maintain the locking state. Subs qu ntly, exhausting the air contained within the oil and th n op ning the opening/closing control valve 57 permits a supply of the hydraulic pressure for lock releasing to the slider 58, and a push of the lock pin 51 out of the engaging hole 59a to thereby control the rotor 30 at an arbitrary angle relative to the case 12.

As mentioned above, according to the first embodiment, through the structure that the engaging hole 59a is closed immediately after the locking state is released, the lock pin 51 is securely prevented from re-engaging with the engaging hole 59a when the engine is running in which the relative rotation between the case 12 and the rotor 30 is permitted.

According to the first embodiment, through the structure that the valve timing adjusting apparatus include the slider 58 serving as a closing member that closes the engaging hole 59a, the slider 58 pushes the lock pin 51 out of the engaging hole 59a to close the engaging hole 59a immediately after the lock is released. This securely prevents the lock pin 51 from re-engaging with the engaging hole 59a when the engine is running.

According to the first embodiment, through the structure that the slider 58 serving as a closing member that closes the engaging hole 59a is slidable in an axial direction of the engaging hole 59a, the slider 58 can be received inside the engaging hol 59a formed along the radial direction of th valve adjustment apparatus 1 in lin with the sliding direction of

th lock pin 51. This r duces th siz of th valv timing adjusting apparatus 1 in its radial direction.

According to the first embodiment, through the structure that the slider 58 serving as a closing member that closes the engaging hole 59a is slidable by hydraulic pressure, the slider 58 can be operated by means of the supply thereto and exhaust therefrom of the hydraulic pressure. This ensures the operating stability of the slider 58.

According to the first embodiment, through the structure that the third oil passage 56 through which the lock releasing hydraulic pressure (the hydraulic pressure) acting on the slider 58 is supplied, is provided independently of the first oil passage 38 and the second oil passage 39 through which the hydraulic pressures for relatively rotating the case 12 (the first rotor) and the rotor 30 (the second rotor) (the advance side hydraulic pressure and the lag side hydraulic pressure) are supplied, the slider 58 can be operated without being influenced at all by fluctuations occurred in the advance side hydraulic pressure and the lag side hydraulic pressure when the engine is running. This secures the independent controllability of the lock releasing operation by the slider 58.

According to the first embodiment, through the structure that the third oil passage 56 through which the lock releasing hydraulic pressure (the hydraulic pressure) acting on the slid r 58 is supplied include the opening/closing control valve 57 controlling the supply and the stop of the lock rel asing

hydraulic pressur , th lock rel asing hydraulic pr ssur can be suppli d at proper lock r leas timing in accordanc with the operating state of the engine and the oil conditions, as well as the lock releasing state is securely maintained as long as the lock releasing hydraulic pressure is supplied.

According to the first embodiment, through the structure that the slider 58 can release the lock even by the lowest hydraulic pressure when the engine is running, it becomes possible to set the urging force of the coil spring 54, for instance, such that the slider 58 is slid against the urging force of the coil spring 54 to thereby maintain the lock releasing state, even though the lock releasing hydraulic pressure applied to the slider 58 is the lowest when the engine is running. This securely prevents at all times the lock pin 51 from re-engaging with the engaging hole 59a when the engine is running.

According to the first embodiment, through the structure that the engaging hole 59a is formed in the outer periphery of the rotor 30 in the position between the most advanced position and the most lagged position, which is the relative position of the rotor 30 (the second rotor), relative to the case 12(the first rotor), the lock pin 51 is securely prevented from re-engaging with the engaging hole 59a, even when performing the intermediate maintaining control in which the rotor 30 is controlled in the intermediate position relative to the case 12.

According to the first embodim nt, since the apparatus

includ s the slider 58 that pushes th lock pin 51 out of the ngaging hole 59a to r l as the ngagem nt of th lock pin 51, and closes the engaging hole 59a, it is possible to use a component for many purposes to suppress an increase in the number of components.

In passing, in the first embodiment, while the apparatus includes the slider 58 that slides in the axial direction of the engaging hole 59a receiving therein the lock pin 51 that slides in a radial direction of the valve timing adjusting apparatus 1, the apparatus may adopt a closing member similar to the slider that slides in a direction crossing the axial direction of the engaging hole 59a, which is introduced in the second embodiment described later, for instance. Moreover, in the first embodiment, although the chambers located on the right side and the left side of the lock pin are atmospheric pressure chambers (the atmospheric pressure chambers 32a and 31b), these chambers may also be hydraulic pressure chambers.

Second Embodiment

FIG. 7 is an axial sectional view showing the internal structure of the valve timing adjusting apparatus according to the second embodiment. FIG. 8 is a radial sectional view taken along line VIII-VIII in FIG. 7. FIG. 9 is an enlarged schematic perspective view showing the purview of FIG. 8. FIG. 10 is an enlarged radial sectional view showing the locking state of the first rotor and the second rotor in the valv timing adjusting apparatus shown in FIGS. 7-9. FIG. 11 is an enlarged radial

sectional view showing the lock r leasing stat of the first rotor and th s cond rotor in th valv timing adjusting apparatus shown in FIGS. 7-9. FIG. 12 is a schematic diagram showing the overall structure of an hydraulic pressure supplying and exhausting system in which the valve timing adjusting apparatus shown in FIGS. 7-11 is incorporated. Among the components in the second embodiment, the same ones as the first embodiment are indicated by the same reference numerals, and therefor the explanation thereof is omitted for brevity's sake.

The feature of the second embodiment is as with the first embodiment in that in a so-called intermediate lock type of valve timing adjusting apparatus, a rotation regulating member that regulates a relative rotation between a first rotor and a second rotor is sidably provided on the slide of the second rotor, in an axial direction of the valve timing adjusting apparatus, an engaging hole receiving therein the rotation regulating member, so-called an axial direction lock, is provided on the first rotor side, and a closing member closing the engaging hole is slidably provided in a direction orthogonally crossing the axial direction of the engaging hole, within the engaging hole.

The second embodiment will now be specifically described below.

A first rotor 10 in the valve timing adjusting apparatus 60 according to the second mbodiment is g nerally composed of a housing 11, a case 70 that is provided adjacent to this housing

11 and has a plurality of (four in the second embodim nt) shoes 70a, 70b, 70c, and 70d radially inwardly projecting to form a plurality of spaces, and a cover 13 that covers the interstice of this case 70, the first rotor being integrally fastened to the apparatus with bolts 14.

As shown in FIG. 7, a second rotor 80 is a rotor (the second rotor 80 is referred to as "a rotor 80" hereinafter) having a boss 80a integrally fastened to the end face of a camshaft 20 with a bolt 21 and a plurality of (four in the second embodiment) vanes 80b, 80c, 80d, and 80e radially outwardly projecting to the outer peripheral of the boss 80a. The vane 80b of the rotor 80 divides the space formed between the shoe 70d and the shoe 70a of the case 70 into an advance side hydraulic pressure chamber 81a and a lag side hydraulic pressure chamber 82a; the vane 80c divides the space formed between the shoe 70a and the shoe 70b into an advance side hydraulic pressure chamber 81b and a lag side hydraulic pressure chamber 82b; the vane 80d divides the space formed between the shoe 70b and the shoe 70c into an advance side hydraulic pressure chamber 81c and a lag side hydraulic pressure chamber 82c; and the vane 80e divides the space formed between the shoe 70c and the shoe 70d into an advance side hydraulic pressure chamber 81d and a lag side hydraulic pressure chamber 82d.

As shown in FIG. 7, in each of the tip ends of the shoes 70a, 70b, 70c, and 70d of the case 70 in the second embodiment are provided seal members 33a, 33b, 33c, and 33d pr venting hydraulic fluid standing between th lag side hydraulic

pressure chamb r 82a and the advance sid hydraulic pressur chamber 81b, between th lag sid hydraulic pr ssur chamber 82b and the advance side hydraulic pressure chamber 81c, between the lag side hydraulic pressure chamber 82c and the advance side hydraulic pressure chamber 81d, and between the lag side hydraulic pressure chamber 82d and the advance side hydraulic pressure chamber 81a, respectively, from flowing, and maintaining the pressure within each of the hydraulic pressure chambers. Moreover, in each of the tip ends of the vanes 80b, 80c, 80d, and 80e of the rotor 80 are provided seal members 33e, 33f, 33g, and 33h preventing hydraulic fluid standing between the advance side hydraulic pressure chamber 81a and the lag side hydraulic pressure chamber 82a, between the advance side hydraulic pressure chamber 81b and the lag side hydraulic pressure chamber 82b, between the advance side hydraulic pressure chamber 81c and the lag side hydraulic pressure chamber 82c, and between the advance side hydraulic pressure chamber 81d and the lag side hydraulic pressure chamber 82d, respectively, from flowing, and maintaining the pressure within each of the hydraulic pressure chambers. As shown in FIG. 8, the seal member 33c, for instance, is generally composed of a seal 34 formed of flexible resin and a board spring 35 pressing the seal 34 to the outer peripheral surface 30f of the rotor 30, and the other seal members have similar structures.

Moreover, assist springs 37 each held by holders 36 are provided b tw n the shoe 70d of th cas 70 and th van 80b of the rotor 80, b tween the sho 70a of the case 70 and the

vane 80c of th rotor 80, b tw en the sho 70b of the case 70 and th vane 80d of the rotor 80, and b twe n the shoe 70c of the case 70 and the vane 80e of the rotor 80. This assist spring 37 continuously urges the rotor 80 relative to the case 70 to the advance direction (in the direction of arrow X in FIG. 7) against the valve reaction force being subject to by the camshaft 20 to the lag direction (in the direction of arrow Y in FIG. 7) at the time hydraulic pressure is not applied when the engine is stopped or started.

Inside the boss 80a of the rotor 80 and the camshaft 20 are provided a first oil passage 38 communicating with the advance side hydraulic pressure chambers 31b, 31c, and 31d other than the advance side hydraulic pressure chamber 81a, and supplying thereto and exhausting therefrom hydraulic pressure, and second oil passage 39 communicating with the lag side hydraulic pressure chambers 82b, 82c, and 82d other than the lag side hydraulic pressure chamber 82a, and supplying thereto and exhausting therefrom hydraulic pressure. The first oil passage 38 and the second oil passage 39 are arranged as shown in FIG. 12 to supply thereto and exhaust therefrom hydraulic pressure by a first oil pump 41 and a second oil pan 42 through an OCV 40. Whereas in the second embodiment as with the first embodiment, hydraulic pressure is not supplied to the advance side hydraulic pressure chamber 81a and the lag side hydraulic pressure chamber 82a, a drain passage (not shown) opened to the atmosphere, for discharging oil is provided within each of th advanc sid hydraulic pressur chamb r 81a and th lag side

hydraulic pressur chamb r 82a.

A lock pin r c iving hole 90 having a bottom 90a in an axial direction of the valve timing adjusting apparatus 60 is formed only in the vane 80b out of the vanes of the rotor 80, disposed between the advance side hydraulic pressure chamber 81a and the lag side hydraulic pressure chamber 82a. In the lock pin receiving hole 90 is slidably provided a lock pin 91 (rotation regulating member) along an axial direction of the lock pin receiving hole 90, for regulating the relative rotation between the case 70 and the rotor 80 when the engine is stopped or started, and for permitting the relative rotation therebetween when the engine is running. The lock pin 91 is generally composed of a cylindrical pin body 91a and a non-through hole 91b formed at the bottom of the pin body 91a in an axial direction of the pin body. In passing, a tip end surface 91c of the pin body 91a has a convexly curved surface with respect to an engaging hole described later, for the same reason of the tip end surface 51c of the pin body 51a in the first embodiment.

Between the bottom 90a of the lock pin receiving hole 90 and the non-through hole 91b of the lock pin 91 is provided a coil spring 54 that continuously urges the lock pin 91 in the direction of arrow Z3. Moreover, within the bottom 90a of the lock pin receiving hole 90 is provided a back pressure drain passage 92 for exhausting the back pressure to the atmosphere, produced in the back of the lock pin 91 when the lock pin 91 retr ats in th dir ction of arrow Z4 against th urging forc of the coil spring 54.

On the oth r hand, at the position within th housing 11 as the first rotor 10, corr sponding to the lock pin r c iving hole 90 formed in the vane 80b of the rotor 80 rotated to the intermediate position between the most advanced position and the most lagged position, is formed a cylindrical engaging hole 93 that extends in an axial direction of the valve timing adjusting apparatus 60 and inserts therein the lock pin 91. The engaging hole 93 has sliding groove 94 in rectangular cross-section form which traverses the central portion of the engaging hole 93, orthogonally crossing the axial direction of the engaging hole (in a radial direction of the housing 11) as shown in FIG. 9. The sliding groove 94 is generally composed of an opening 94a opened to the vane 80b of the rotor 80, located inside in a radial direction of the housing 11, an opening 94b opened to a third oil passage 56 provided within the camshaft 20, and a bottom 94c having a cross-section that is smaller than that of the opening 94b, located outside the housing 11 in a radial direction thereof. Within this sliding groove 94 is provided a slider 95 (closing member) being subject to hydraulic pressure (lock releasing hydraulic pressure) supplied by the third oil passage 56, to slide in the direction of arrow Z2, thereby releasing the engagement of the lock pin 91 and closing the engaging hole 93.

The slider 95 is generally composed of a head 95a in rectangular cross-section form, a body 95b having a rectangular cross-s ction that is longer than the length of this head 95a in an axial dir ction of the valve timing adjusting apparatus

60, a ramp d portion 95c conn ct d b twe n on surfac of this body 95b, located on the rotor 80 side and on surface of the head 95a, located on the rotor 80 side, a bottom surface 95d serving as a pressure surface, which is located on the body 95b side, and is subject to the lock releasing hydraulic pressure supplied by the third oil passage 56, and a non-through hole 95e formed in the top surface of the head 95a. A coil spring 96 that continuously urges the slider 95 in the direction of arrow Z1 is provided between the non-through hole 95e of this slider 95 and the bottom 94c of the sliding groove 94.

In addition, as shown in FIG. 8, in the bottom 94c of the sliding groove 94 is formed a pressure drain passage 97 that extends to the housing 11 side, opposed to the rotor 80 side. The pressure drain passage 97 is responsible for exhausting the air existing in the space between the head 95a of the slider 95 and the bottom 94c of the sliding groove 94 to the atmosphere when the slider 95 is subject to lock releasing hydraulic pressure supplied by the third oil passage 56, on the bottom surface 95d, and slides in the direction of arrow Z2 against the urging force of the coil spring 96, and for reducing sliding resistance of the slider 95.

The operation of the second embodiment will now be described below.

First of all, since an oil pump 41 shown in FIG. 12 is not driven when the engine is stopped, the remaining oil in the valve timing adjusting apparatus 1, th first oil passage 38, and the second oil passage 39 is flowed to oil pan 42. At that time,

becaus an op ning/closing control valv 57 is clos d, and the hydraulic pressure is not suppli d to the third oil passag 56, the lock releasing hydraulic pressure from the third oil passage 56 does not act on the bottom surface 95d of the slider 95. Therefore, as shown in FIG. 9 and FIG. 10, the slider 95 slides in the direction of arrow Z1 by the urging force of the coil spring 96, and the bottom surface 95c is returned to the position of the opening surface 94b of the sliding groove 94. At that time, the bottom surface 95c of the slider 95 abuts the outer peripheral surface of the camshaft 20 on which the third oil passage 56 is opened. In this state, because in the engaging hole 93 is positioned the head 95a that is shorter, in an axial direction of the valve timing adjusting apparatus 60, than the length of the body 95b of the slider 95, the lock pin 91 sliding in the direction of arrow Z3 by the urging force of the coil spring 54 is allowed to engage with the engaging hole 93 until the tip end surface 91c of the lock pin 91 abuts the side surface of the head 95a of the slider 95 as shown in FIG. 8 and FIG. 10. This regulates the relative rotation between the housing 11 and the case 70 as the first rotor 10, and the rotor 80 (the locking state).

Subsequently, since it is difficult to control the relative rotation between the first rotor and the second rotor of the valve timing adjusting apparatus 60 at the desired position on account of a low temperature and a high viscosity of th oil imm diat ly after the engin is started and th pump 41 in FIG. 12 is driven, the opening/closing control valv 57

is closed, and th slid r 95 do s not act on th lock pin 91, ther by maintaining th locking state.

Then, when the engine warming up is ended, the oil gets to have a high temperature and a low viscosity. At this stage, it becomes fairly possible to control the relative rotation between the first rotor and the second rotor of the valve timing adjusting apparatus 60 at the desired position. Now, upon giving a control instruction, the opening/closing control valve 57 shown in FIG. 12 is operated to change from the closing state to the opening state in which the hydraulic pressure is supplied to the third oil passage 56, which acts the hydraulic pressure (the lock releasing hydraulic pressure) supplied from the third oil passage 56 on the bottom surface 95d of the slider 95. The slider 95 slides in the direction of arrow Z2 by the hydraulic pressure, as shown in FIG. 11. The tip end surface 91c of the lock pin 91 slides on the ramped portion 95c from the side surface of the head 95a of the slider 95 accompanied with this slide of the slider 95, and comes to abut the side surface of the body 95b. At that time, the lock pin 91 is returned in the direction of arrow Z4 against the urging force of the coil spring 54 as many as the stroke (distance) corresponding to the dimensional difference in length between the head 95a and the body 95b of the slider 95 in an axial direction of the valve timing adjusting apparatus 60. This causes the lock pin 91 to be came out of the engaging hole 93 (the engagement is released.), permitting the relative rotation between the housing 11 and the case 70 as the first rotor 10, and the rotor 80 (the lock releasing state).

This lock r leasing state is s cur ly maintain d b cause the engaging hol 93 is clos d by th slider 95 slid by th lock releasing hydraulic pressure as long as the lock releasing hydraulic pressure is supplied through the third oil passage 56 with the opened opening/closing control valve 57.

Moreover, since the third oil passage 56 is constructed independently of the first oil passage 38 and the second oil passage 39 communicating with the advance side hydraulic pressure chambers 81b, 81c, and 81d, and the lag side hydraulic pressure chambers 82b, 82c, and 82d in which the hydraulic pressure fluctuations accompanied with the change in the relative angle between the case 70 and the rotor 80 takes place when the engine is running, the third oil passage 56 is not influenced by the fluctuations in the above-mentioned hydraulic pressure, and can continue applying a constant lock releasing hydraulic pressure to the slider 95.

In addition, because the air existing in the space between the head 95a of the slider 95 and the bottom 94c of the sliding groove 94 is exhausted to the atmosphere through the pressure drain passage 97 when the slider 95 slides in the direction of arrow Z2, the sliding resistance of the slider 95 is extremely small. Accordingly, the slider 95 promptly slides by the applied lock releasing hydraulic pressure, push the lock pin 91 out of the engaging hole 93, and close the engaging hole 93. In passing, the urging force of the coil spring 54, for instance, is set such that th slider 95 slid s against the urging forc of the coil spring 54, to allow to maintain the lock releasing

state ev n wh n th lock releasing hydraulic pr ssure applied to th slider 95 is the lowest when the ngin is running.

Since the lock pin 91 is continuously urged in the direction of arrow Z1 by the urging force of the coil spring 54 even when the engine is running, the lock pin slides on the side surface of the housing 11 at the time the housing 11 as the first rotor 10 and the rotor 80 are relatively rotated. On the other hand, because the engaging hole 93 is always closed by the slider 95, the lock pin 91 is securely prevented from re-engaging with the engaging hole 93 no matter whatever the valve timing adjusting apparatus 60 is in controlling state. For instance, when performing the intermediate maintaining control in which the relative angle between the housing 11 and the case 70 as the first rotor 10 and the rotor 80, such that the vane 80b of the rotor 80 is maintained in the intermediate position in which the vane of the rotor is apart from both of the shoe 70d and the shoe 70a of the case 70, the lock pin 91 will slide in the proximity of the engaging hole 93. However, even in this case, because the engaging hole 93 is closed by the slider 95, the lock pin 91 is securely prevented from re-engaging with the engaging hole 93.

In addition, once the engine stopped, the remaining oil within the first oil passage 38 and the second oil passage 39 flowed down to the oil pan 42, and air comes to stay in each oil passage. If the engine is re-started under such a condition, it is difficult to control the valve timing adjusting apparatus 60 in the substantially intermediate position between th most

advanc d position and th most lagged position for th reason that the oil supplied from th first oil passage 38 and the s cond oil passage 39 into the valve timing adjusting apparatus 60 contains air therein even though the oil has a high temperature and a low viscosity. Even in this case, closing the opening/closing control valve 57 allows a stop of the supply of the hydraulic pressure for lock releasing to the slider 95, thereby maintaining the locking state. Subsequently, opening the opening/closing control valve 57 after the air contained within the oil permits supply of the hydraulic pressure for lock releasing to the slider 95, which pushes the lock pin 91 out of the engaging hole 93, thereby controlling the rotor 80 at an (arbitrarily) desirable angle relative to the housing 11 and the case 70 as the first rotor 10.

As mentioned above, according to the second embodiment through the structure that the slider 95 serving as a closing member that closes the engaging hole 93 is slidable in a direction orthogonally crossing the axial direction of the engaging hole 93 in addition to various effects brought about by the structure according to the first embodiment and the modifications thereof, the slider 95 can be received inside the engaging hole 93 formed in the direction in which the lock pin 91 slides along the axial direction of the valve timing adjusting apparatus 60. This reduces the size of the valve timing adjusting apparatus 60 in its radial direction. While, in th second mbodiment, the slider 95 slid s in a direction orthogonally crossing the axial dir ction of the engaging hol

93, th slider may slide not only in a dir ction orthogonally crossing the axial direction of th ngaging hole, but also in a direction crossing the axial direction of the engaging hole.

Although, in the second embodiment, it is arranged such that the valve timing adjusting apparatus includes the slider sliding in a direction crossing the axial direction of the engaging hole 93 receiving therein the lock pin 91 sliding in an axial direction of the valve timing adjusting apparatus 60, the valve timing adjusting apparatus may adopt, within the engaging hole 93, a closing member that slides in an axial direction of the engaging hole 93, that is, it has such the slider 51 as with the first embodiment, for instance.

In passing, although so-called intermediate lock type valve timing adjusting apparatus 1, 60 are disclosed in the first embodiment and second embodiment, the present invention is also applicable to the most advanced lock type valve timing adjusting apparatus which regulates the rotation of the second rotor relative to the first rotor at the most advanced position and the most lagged lock type valve timing adjusting apparatus which regulates the rotation of the second rotor relative to the first rotor at the most lagged position.

While, in the first embodiment and the second embodiment, the sliders 58 and 95 sliding by hydraulic pressure are adopted to close the engaging holes 59a and 93, the present invention is not necessarily limited to the closing members such as the above-m ntioned closing m mb rs, any means may be adopted insofar as one uses means for preventing the lock pins 51 and

91 r gulating the r lative rotations b tw n th first rotor 10 and th second rotors 30, 80 from r - ngaging with th engaging hole, no matter whatever structure the means has therein. Other means such as a diaphragm in which its film surface vertically moves by hydraulic pressure within the engaging holes 59a and 93, for instance, may be optionally used to close the engaging holes 59a and 93.

Additionally, although in the first embodiment and second embodiment, it is arranged such that the supply and the stop of lock releasing hydraulic pressure to the sliders 58 and 95 serving as the closing member is controlled by the opening/closing operation of the oil passage of the opening/closing control valve 57, such as a method of elongating the oil passage length of the third oil passage 56 or providing a restrictor within the third oil passage 56 can be adequately adopted as necessary, as a method of causing the lock pins 51, 91 stay within the engaging holes 59a, 93, respectively, for a predetermined period of time by delaying the time of supplying hydraulic pressure acting on the sliders 58, 95 that push the lock pins 51, 91 out of the engaging holes relative to the time of supplying hydraulic pressure required for causing the relative rotation between the first rotor 10 and the second rotors 30, 80 immediately after the engine is started.